MVA : Telecom Churn Prediction

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April 22, 2019

library(readr)  
library(ggplot2)  
library(dplyr)

##   
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':  
##   
## filter, lag

## The following objects are masked from 'package:base':  
##   
## intersect, setdiff, setequal, union

library(tidyr)

## Warning: package 'tidyr' was built under R version 3.5.3

library(corrplot)

## corrplot 0.84 loaded

library(caret)

## Warning: package 'caret' was built under R version 3.5.3

## Loading required package: lattice

library(rms)

## Warning: package 'rms' was built under R version 3.5.3

## Loading required package: Hmisc

## Warning: package 'Hmisc' was built under R version 3.5.3

## Loading required package: survival

##   
## Attaching package: 'survival'

## The following object is masked from 'package:caret':  
##   
## cluster

## Loading required package: Formula

##   
## Attaching package: 'Hmisc'

## The following objects are masked from 'package:dplyr':  
##   
## src, summarize

## The following objects are masked from 'package:base':  
##   
## format.pval, units

## Loading required package: SparseM

##   
## Attaching package: 'SparseM'

## The following object is masked from 'package:base':  
##   
## backsolve

library(MASS)

## Warning: package 'MASS' was built under R version 3.5.3

##   
## Attaching package: 'MASS'

## The following object is masked from 'package:dplyr':  
##   
## select

library(e1071)

## Warning: package 'e1071' was built under R version 3.5.3

##   
## Attaching package: 'e1071'

## The following object is masked from 'package:Hmisc':  
##   
## impute

library(ROCR)

## Warning: package 'ROCR' was built under R version 3.5.3

## Loading required package: gplots

## Warning: package 'gplots' was built under R version 3.5.3

##   
## Attaching package: 'gplots'

## The following object is masked from 'package:stats':  
##   
## lowess

library(gplots)  
library(pROC)

## Warning: package 'pROC' was built under R version 3.5.3

## Type 'citation("pROC")' for a citation.

##   
## Attaching package: 'pROC'

## The following objects are masked from 'package:stats':  
##   
## cov, smooth, var

library(rpart)

##   
## Attaching package: 'rpart'

## The following object is masked from 'package:survival':  
##   
## solder

library(randomForest)

## Warning: package 'randomForest' was built under R version 3.5.3

## randomForest 4.6-14

## Type rfNews() to see new features/changes/bug fixes.

##   
## Attaching package: 'randomForest'

## The following object is masked from 'package:dplyr':  
##   
## combine

## The following object is masked from 'package:ggplot2':  
##   
## margin

library(ggpubr)

## Warning: package 'ggpubr' was built under R version 3.5.3

## Loading required package: magrittr

##   
## Attaching package: 'magrittr'

## The following object is masked from 'package:tidyr':  
##   
## extract

library(tidyverse)

## -- Attaching packages -------------------------------------- tidyverse 1.2.1 --

## v tibble 2.0.1 v stringr 1.4.0  
## v purrr 0.3.0 v forcats 0.3.0

## -- Conflicts ----------------------------------------- tidyverse\_conflicts() --  
## x randomForest::combine() masks dplyr::combine()  
## x magrittr::extract() masks tidyr::extract()  
## x dplyr::filter() masks stats::filter()  
## x dplyr::lag() masks stats::lag()  
## x purrr::lift() masks caret::lift()  
## x randomForest::margin() masks ggplot2::margin()  
## x MASS::select() masks dplyr::select()  
## x purrr::set\_names() masks magrittr::set\_names()  
## x Hmisc::src() masks dplyr::src()  
## x Hmisc::summarize() masks dplyr::summarize()

library(magrittr)  
library(data.table)

##   
## Attaching package: 'data.table'

## The following object is masked from 'package:purrr':  
##   
## transpose

## The following objects are masked from 'package:dplyr':  
##   
## between, first, last

library(reshape2)

## Warning: package 'reshape2' was built under R version 3.5.3

##   
## Attaching package: 'reshape2'

## The following objects are masked from 'package:data.table':  
##   
## dcast, melt

## The following object is masked from 'package:tidyr':  
##   
## smiths

library(stats)

telcoCust <- read.csv("C:/Users/sawan/OneDrive/Desktop/Backup KPS/Rutgers Courses/Sem 2/MA/project/Telco-Customer-Churn.csv")  
#View(telcoCus)  
str(telcoCust)

## 'data.frame': 7043 obs. of 21 variables:  
## $ customerID : Factor w/ 7043 levels "0002-ORFBO","0003-MKNFE",..: 5376 3963 2565 5536 6512 6552 1003 4771 5605 4535 ...  
## $ gender : Factor w/ 2 levels "Female","Male": 1 2 2 2 1 1 2 1 1 2 ...  
## $ SeniorCitizen : int 0 0 0 0 0 0 0 0 0 0 ...  
## $ Partner : Factor w/ 2 levels "No","Yes": 2 1 1 1 1 1 1 1 2 1 ...  
## $ Dependents : Factor w/ 2 levels "No","Yes": 1 1 1 1 1 1 2 1 1 2 ...  
## $ tenure : int 1 34 2 45 2 8 22 10 28 62 ...  
## $ PhoneService : Factor w/ 2 levels "No","Yes": 1 2 2 1 2 2 2 1 2 2 ...  
## $ MultipleLines : Factor w/ 3 levels "No","No phone service",..: 2 1 1 2 1 3 3 2 3 1 ...  
## $ InternetService : Factor w/ 3 levels "DSL","Fiber optic",..: 1 1 1 1 2 2 2 1 2 1 ...  
## $ OnlineSecurity : Factor w/ 3 levels "No","No internet service",..: 1 3 3 3 1 1 1 3 1 3 ...  
## $ OnlineBackup : Factor w/ 3 levels "No","No internet service",..: 3 1 3 1 1 1 3 1 1 3 ...  
## $ DeviceProtection: Factor w/ 3 levels "No","No internet service",..: 1 3 1 3 1 3 1 1 3 1 ...  
## $ TechSupport : Factor w/ 3 levels "No","No internet service",..: 1 1 1 3 1 1 1 1 3 1 ...  
## $ StreamingTV : Factor w/ 3 levels "No","No internet service",..: 1 1 1 1 1 3 3 1 3 1 ...  
## $ StreamingMovies : Factor w/ 3 levels "No","No internet service",..: 1 1 1 1 1 3 1 1 3 1 ...  
## $ Contract : Factor w/ 3 levels "Month-to-month",..: 1 2 1 2 1 1 1 1 1 2 ...  
## $ PaperlessBilling: Factor w/ 2 levels "No","Yes": 2 1 2 1 2 2 2 1 2 1 ...  
## $ PaymentMethod : Factor w/ 4 levels "Bank transfer (automatic)",..: 3 4 4 1 3 3 2 4 3 1 ...  
## $ MonthlyCharges : num 29.9 57 53.9 42.3 70.7 ...  
## $ TotalCharges : num 29.9 1889.5 108.2 1840.8 151.7 ...  
## $ Churn : Factor w/ 2 levels "No","Yes": 1 1 2 1 2 2 1 1 2 1 ...

# Change Senior Citizen into factor  
(telcoCust$SeniorCitizen <- factor(telcoCust$SeniorCitizen))

## [1] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 1 0 0  
## [35] 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 1 1 0 1 0 0 0 0 0 0 0 0 0 0  
## [69] 0 0 0 0 1 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0  
## [103] 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0  
## [137] 0 0 0 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0  
## [171] 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0  
## [205] 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0  
## [239] 1 0 0 0 0 1 1 1 0 1 0 0 0 0 1 0 0 0 0 0 0 1 1 1 1 0 0 0 0 1 0 0 1 0  
## [273] 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0  
## [307] 1 0 1 0 0 0 0 1 0 0 0 0 1 0 1 0 0 0 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0  
## [341] 1 0 0 0 0 1 0 0 0 1 0 0 1 0 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0  
## [375] 0 0 0 0 0 0 0 0 1 0 0 1 1 0 0 0 0 1 1 0 1 0 1 0 1 0 0 0 0 0 0 0 0 1  
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## [477] 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 1 0 0 0 1 0 0 0 0  
## [511] 1 0 1 0 0 0 0 1 1 0 0 1 0 0 0 0 1 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0  
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## [783] 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0  
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## [6903] 1 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0  
## [6937] 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 1 0 1 0 0 1 0 1 1 0  
## [6971] 0 1 1 1 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0  
## [7005] 0 0 0 1 1 0 1 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 1 1 0 0 0 0 0  
## [7039] 0 0 0 1 0  
## Levels: 0 1

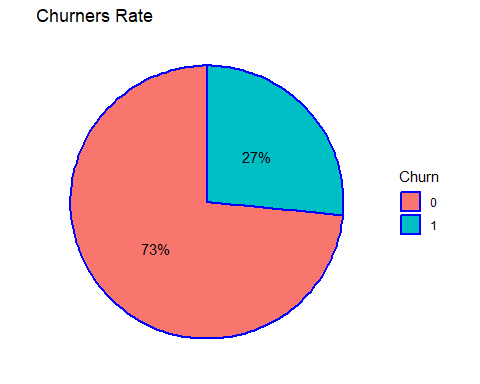
# Factor the response variable into 0, 1  
(telcoCust$Churn <- factor(ifelse(telcoCust$Churn == 'No', 0, 1)))

## [1] 0 0 1 0 1 1 0 0 1 0 0 0 0 1 0 0 0 0 1 0 1 0 1 0 0 0 1 1 0 1 0 0 0 0  
## [35] 0 0 1 0 1 1 0 0 0 0 0 0 0 1 0 0 0 1 0 1 0 1 0 0 0 0 0 0 0 0 1 0 0 0  
## [69] 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 1 0 0  
## [103] 0 0 1 0 0 0 0 0 1 0 0 1 0 0 0 1 0 0 0 0 1 0 0 0 1 0 0 0 0 1 0 1 1 0  
## [137] 0 0 0 1 0 1 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 1 0  
## [171] 0 1 0 1 0 0 1 1 0 0 1 0 1 0 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0  
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## [4251] 0 0 0 0 1 1 0 0 1 1 0 0 1 0 0 1 1 0 0 1 0 0 1 1 0 0 1 0 0 0 0 0 0 0  
## [4285] 0 0 0 1 1 0 1 0 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 1 1 0 0  
## [4319] 0 0 0 0 0 1 0 0 1 0 0 1 1 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 1 1 0 0  
## [4353] 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0  
## [4387] 1 0 0 0 0 0 0 1 0 1 1 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 1 0  
## [4421] 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 1 0 1 0 1 0 0 1  
## [4455] 0 1 0 0 1 1 0 0 1 1 1 0 1 0 1 0 0 1 0 0 0 0 1 0 0 0 1 0 1 0 0 0 0 0  
## [4489] 1 0 0 0 0 0 0 1 0 0 0 1 0 0 1 1 0 0 0 0 0 1 0 0 0 1 0 0 0 1 1 0 1 0  
## [4523] 0 0 1 0 0 1 0 0 0 1 1 0 0 1 1 0 1 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 0 0  
## [4557] 1 0 1 0 0 0 0 1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0  
## [4591] 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 1 0 0 0 0  
## [4625] 1 0 0 0 0 0 0 1 1 0 0 0 0 0 1 0 1 0 1 0 0 1 0 0 0 0 0 1 0 1 0 0 0 0  
## [4659] 0 0 1 0 0 1 1 0 0 0 0 0 0 1 0 1 0 1 0 1 1 0 0 1 1 0 1 0 0 1 0 0 0 1  
## [4693] 0 0 0 0 0 0 1 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 1 0 1  
## [4727] 0 0 0 0 0 0 0 0 1 0 0 0 1 0 1 0 0 0 0 0 1 0 0 1 0 1 0 1 0 0 0 1 0 1  
## [4761] 0 0 0 0 1 0 0 0 0 0 0 1 0 1 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 1 0  
## [4795] 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 1 1 0 1 1 0 0 0 1 0 0 0 1 0 0 1 1  
## [4829] 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 0 0 0 0 1 1 0 0 1 0 0 0 0 1 0 0 0 0 0  
## [4863] 1 0 0 0 0 0 1 0 0 0 0 0 1 1 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0  
## [4897] 0 0 1 1 1 1 0 1 0 0 0 0 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0  
## [4931] 0 0 0 0 0 0 0 0 1 0 0 1 1 0 0 0 1 1 0 1 1 0 0 0 1 1 1 0 0 1 1 0 0 0  
## [4965] 1 1 0 1 0 0 0 0 0 0 1 0 0 0 1 0 0 1 1 1 0 0 0 0 0 0 0 1 0 0 1 1 0 1  
## [4999] 0 0 0 1 0 1 0 1 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 1 0 0 1 0  
## [5033] 0 0 0 0 1 1 0 1 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 1 1 1 0  
## [5067] 0 0 0 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 1 1 0 0 0 0 0 0 1 1  
## [5101] 1 0 0 0 0 1 0 0 0 0 0 1 1 0 0 0 1 0 0 0 1 0 0 1 0 1 0 1 0 0 1 1 0 1  
## [5135] 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0  
## [5169] 1 0 0 0 0 0 1 0 0 1 0 1 0 0 0 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0  
## [5203] 0 0 0 0 0 1 0 0 1 1 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 1 0 0  
## [5237] 0 0 0 0 0 0 1 0 0 0 1 1 0 0 0 1 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0  
## [5271] 1 0 1 0 0 1 0 1 0 0 0 0 1 0 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0  
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## [5407] 0 0 0 1 0 1 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 1 0 1 0 0 0 0 1 1 1  
## [5441] 0 1 0 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0  
## [5475] 0 1 1 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 1 1 1 0 1 1 1 0 0 1 0 1 0 0 0  
## [5509] 0 1 0 0 0 0 0 0 1 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 1 1  
## [5543] 0 0 1 0 0 1 0 1 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0  
## [5577] 1 0 0 1 0 1 0 1 1 1 0 0 1 1 0 1 0 0 0 0 0 1 0 1 1 0 0 1 0 0 0 1 0 1  
## [5611] 1 0 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 0 1 1 1 0 0 0 1 0 1 0 1 0 1 0 0 1  
## [5645] 1 0 1 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0  
## [5679] 1 1 1 0 0 1 1 0 1 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 1 0 0 0 1 0 0 0 0 1  
## [5713] 0 0 1 1 0 0 1 0 0 0 1 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0  
## [5747] 1 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1  
## [5781] 0 0 1 1 0 0 0 1 0 0 0 0 1 0 0 0 0 0 1 1 0 0 0 1 0 0 1 0 0 0 1 0 1 0  
## [5815] 0 1 0 1 0 0 0 0 0 0 0 1 1 0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0  
## [5849] 0 0 1 0 1 0 0 0 0 1 0 0 1 0 0 1 0 0 0 0 0 0 1 1 1 0 1 0 1 1 0 0 1 0  
## [5883] 0 0 1 0 0 0 1 0 0 1 0 0 1 0 0 0 0 0 1 1 0 0 0 0 1 0 1 0 0 0 1 0 0 0  
## [5917] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 1 0 0 0 0 1 1 1 0 1 1 0 0  
## [5951] 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 1 1 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0  
## [5985] 1 0 0 0 0 1 0 1 1 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 1 0 0 0 1 0  
## [6019] 0 0 0 0 0 0 1 0 0 0 1 0 1 0 1 1 0 1 0 0 1 1 1 0 0 1 0 0 0 0 1 0 0 0  
## [6053] 0 0 1 0 0 0 0 0 0 0 0 0 1 0 1 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 1 0 0 1  
## [6087] 0 0 1 1 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0  
## [6121] 0 0 0 0 0 1 1 0 0 0 0 1 0 0 0 0 0 1 0 0 0 1 1 0 0 0 1 0 0 0 0 1 1 0  
## [6155] 0 1 0 1 0 0 0 0 0 0 0 0 1 0 1 1 0 0 1 0 1 0 1 1 0 1 0 0 0 0 0 0 1 0  
## [6189] 0 0 1 0 0 0 0 1 0 1 0 1 0 0 1 0 0 1 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0  
## [6223] 0 1 0 0 0 1 0 0 0 1 1 0 0 1 0 1 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0  
## [6257] 1 1 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 1 0 0 0 1 0 1  
## [6291] 1 0 0 0 1 0 0 0 0 0 0 0 1 0 1 1 0 0 0 0 0 0 1 1 0 0 0 1 0 0 0 1 1 0  
## [6325] 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 1 0 0 1 0 1 0 0 0 0 1 0 0 0 0 0 1  
## [6359] 0 0 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 1 0 1 1 1 0 0 0 0 0 1 0 0 1 0 0 0  
## [6393] 0 0 0 1 0 0 1 0 0 1 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 1 0  
## [6427] 0 0 1 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 1 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0  
## [6461] 1 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 1 0 0 0 1 0 1 1 0 1 0 0  
## [6495] 0 1 1 0 1 0 0 0 0 0 1 0 1 1 1 1 0 0 0 0 0 1 1 0 1 0 1 0 0 0 1 0 1 1  
## [6529] 0 1 0 0 0 0 0 1 0 1 1 0 0 0 1 0 1 1 0 0 0 1 1 0 1 0 1 0 0 0 1 0 0 0  
## [6563] 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 0 0  
## [6597] 0 1 0 1 1 0 0 0 0 1 1 1 1 1 0 0 1 0 0 0 1 0 0 0 1 0 1 1 0 1 1 0 0 0  
## [6631] 0 0 1 1 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 1 0 0 0  
## [6665] 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0  
## [6699] 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 1 0 1 0 0 0 0 0  
## [6733] 0 0 1 0 0 0 0 0 1 1 0 0 0 1 1 0 1 0 0 0 0 0 0 0 0 1 0 0 1 0 1 0 1 0  
## [6767] 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 1 0 0 0 1 1 0 0 1 0 1 1 0 0 0 1 0 0 0  
## [6801] 1 0 0 0 0 0 0 0 0 1 1 1 0 1 0 0 1 0 0 1 0 1 1 0 1 0 0 0 0 0 0 1 0 0  
## [6835] 0 0 1 0 1 1 0 0 0 1 0 0 1 0 0 0 0 0 0 1 0 0 0 0 1 0 1 1 1 0 1 0 1 0  
## [6869] 1 1 0 0 0 0 0 0 0 1 1 0 0 0 0 0 1 1 1 0 0 0 0 0 0 1 1 0 1 0 0 1 0 0  
## [6903] 0 0 0 0 0 1 1 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 1 0 1 0 0 0 1 0 0 1 0 0  
## [6937] 1 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 1 1 0 0 0 0 1 1 1  
## [6971] 1 1 1 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 1 0 1 0 0 1 0 0 1 0 1 0 0  
## [7005] 0 0 1 0 1 1 1 1 0 0 0 0 0 0 1 0 0 1 0 0 0 0 1 0 0 0 0 0 1 0 1 0 0 0  
## [7039] 0 0 0 1 0  
## Levels: 0 1

# replace missing data with mean values  
(telcoCust$TotalCharges <- ifelse(is.na(telcoCust$TotalCharges),ave(telcoCust$TotalCharges, FUN = function(x) mean(x, na.rm=TRUE)),telcoCust$TotalCharges))

## [1] 29.85 1889.50 108.15 1840.75 151.65 820.50 1949.40 301.90  
## [9] 3046.05 3487.95 587.45 326.80 5681.10 5036.30 2686.05 7895.15  
## [17] 1022.95 7382.25 528.35 1862.90 39.65 202.25 20.15 3505.10  
## [25] 2970.30 1530.60 4749.15 30.20 6369.45 1093.10 6766.95 181.65  
## [33] 1874.45 20.20 45.25 7251.70 316.90 3548.30 3549.25 1105.40  
## [41] 475.70 4872.35 418.25 4861.45 981.45 3906.70 97.00 144.15  
## [49] 4217.80 4254.10 3838.75 1426.40 1752.65 633.30 4456.35 1752.55  
## [57] 6311.20 7076.35 894.30 7853.70 4707.10 5450.70 2962.00 957.10  
## [65] 857.25 244.10 3650.35 2497.20 930.90 887.35 49.05 1090.65  
## [73] 7099.00 1424.60 177.40 6139.50 2688.85 482.25 2111.30 1216.60  
## [81] 79.35 565.35 496.90 4327.50 973.35 918.75 2215.45 1057.00  
## [89] 927.10 1009.25 2570.20 74.70 5714.25 7107.00 7459.05 927.35  
## [97] 4748.70 113.85 1107.20 2514.50 20.20 19.45 3605.60 3027.25  
## [105] 7611.85 100.20 7303.05 927.65 3921.30 1363.25 5238.90 3042.25  
## [113] 3954.10 2868.15 3423.50 248.40 1126.35 1064.65 835.15 2151.60  
## [121] 5515.45 112.75 229.55 350.35 62.90 3027.65 2135.50 1723.95  
## [129] 19.75 3985.35 1215.65 1502.65 3260.10 35.45 81.25 1188.20  
## [137] 1778.50 1277.75 1170.55 70.45 6425.65 563.65 5971.25 5289.05  
## [145] 1756.20 6416.70 61.35 45.65 1929.95 1071.40 564.35 655.50  
## [153] 7930.55 5215.25 113.50 1152.80 1821.95 419.90 1024.00 251.60  
## [161] 764.55 1592.35 135.20 3958.25 233.90 1363.45 273.00 6254.45  
## [169] 2651.20 321.40 3539.25 242.80 1181.75 5000.20 654.55 780.20  
## [177] 1145.70 503.60 1559.25 1252.00 29.95 45.30 662.65 2453.30  
## [185] 1111.65 24.80 1023.85 82.15 244.80 2379.10 3173.35 531.00  
## [193] 1375.40 8129.30 1192.70 1901.65 587.40 6519.75 8041.65 20.75  
## [201] 2681.15 1112.30 7405.50 1033.95 2958.95 2684.85 4179.20 79.90  
## [209] 1934.45 6654.10 84.50 25.25 1124.20 540.05 1975.85 3437.45  
## [217] 3139.80 3789.20 5324.50 624.60 268.35 1836.90 20.20 179.35  
## [225] 219.35 1288.75 2545.75 55.20 2723.15 4107.25 5760.65 4747.50  
## [233] 84.60 1566.90 702.00 114.10 299.05 1305.95 1120.30 284.35  
## [241] 6350.50 7878.30 3187.65 6126.15 731.30 273.40 2531.80 1074.30  
## [249] 48.55 4298.45 4619.55 147.15 40.20 2633.30 193.05 4103.90  
## [257] 7008.15 5791.10 80.55 1228.65 132.20 1364.30 4925.35 1520.10  
## [265] 5032.25 5526.75 1195.25 2007.25 1099.60 1732.95 1511.20 3450.15  
## [273] 24.80 2172.05 70.60 401.10 5624.85 1339.80 771.95 244.75  
## [281] 322.90 498.25 25.40 3687.75 1779.95 1783.60 927.15 70.00  
## [289] 606.55 435.40 1712.70 2021.20 1940.80 567.80 220.35 20.25  
## [297] 5436.45 3437.50 3015.75 73.60 1509.80 396.10 356.65 4109.00  
## [305] 3141.70 1229.10 2303.35 2054.40 3741.85 3682.45 19.25 1886.25  
## [313] 4895.10 341.60 415.55 5686.40 1355.10 3058.65 2231.05 3236.35  
## [321] 4350.10 4264.00 44.80 422.30 4176.70 5138.10 880.05 139.05  
## [329] 973.65 1470.05 739.35 161.95 4422.95 511.25 155.80 5293.95  
## [337] 4759.85 6148.45 3565.65 6603.00 1830.10 6223.80 4508.65 1328.15  
## [345] 865.00 72.10 168.20 1303.50 996.85 6430.90 2278.75 681.40  
## [353] 574.35 371.90 840.10 846.00 889.00 6823.40 805.10 4016.75  
## [361] 83.75 3959.15 2878.55 945.70 1373.05 492.55 1406.00 19.15  
## [369] 6962.85 8126.65 690.25 181.50 830.80 5608.40 3646.80 3662.25  
## [377] 25.35 2566.50 5308.70 1410.25 3339.05 50.65 4732.35 90.85  
## [385] 5067.45 214.75 4874.70 2348.45 4063.00 44.00 2595.25 2309.55  
## [393] 89.30 367.55 3944.50 5965.95 3694.70 2524.45 1803.70 415.10  
## [401] 624.15 237.70 7007.60 3848.80 419.40 1468.75 5812.00 2861.45  
## [409] 19.90 19.60 233.70 1066.15 2149.05 4473.00 3545.05 1195.75  
## [417] 6858.90 1024.70 1845.90 75.30 132.25 515.45 2830.45 1110.50  
## [425] 449.30 2838.55 5376.40 858.60 1395.05 3975.70 1182.55 4784.45  
## [433] 119.50 518.90 899.45 1183.80 720.05 8468.20 3161.20 55.05  
## [441] 1882.55 5070.40 6049.50 1166.70 2937.65 6396.45 69.55 1270.25  
## [449] 759.55 7611.55 1642.75 1545.40 3582.40 2227.10 1417.90 2494.65  
## [457] 2768.35 2369.30 38.00 75.10 100.90 1614.05 385.90 673.25  
## [465] 8404.90 2799.75 6538.45 6588.95 868.10 734.35 330.60 55.00  
## [473] 564.40 1315.35 74.70 1861.50 2747.20 554.05 453.40 994.80  
## [481] 225.75 2145.00 1671.60 8003.80 680.05 6130.85 1415.00 6201.95  
## [489] 2283.30 74.35 6597.25 114.15 139.40 3902.60 20.40 903.60  
## [497] 1785.65 1397.65 131.05 1238.45 3899.05 5676.00 4543.15 4326.80  
## [505] 5502.55 1782.40 851.80 167.50 502.85 19.85 1818.30 6300.15  
## [513] 334.80 5916.95 2852.40 4131.95 1546.30 302.60 1929.35 265.45  
## [521] 6989.45 1442.00 4713.40 1758.60 3480.00 4738.30 8399.15 5430.35  
## [529] 686.95 5706.30 490.65 1360.25 174.45 7379.80 85.00 1021.75  
## [537] 5029.05 1955.40 6744.20 4946.70 8248.50 601.60 19.55 834.10  
## [545] 597.00 2647.20 3266.00 6744.25 5265.50 311.60 7966.90 8220.40  
## [553] 1153.25 514.75 2596.15 3808.00 19.90 2708.20 760.05 49.30  
## [561] 6033.30 89.05 516.15 5861.75 445.95 4973.40 1667.25 5357.75  
## [569] 3527.60 422.60 1103.25 2754.00 697.25 5614.45 3204.40 4747.65  
## [577] 3082.10 597.90 3365.40 38.80 233.55 75.30 346.20 19.00  
## [585] 61.70 85.70 3342.45 85.10 7422.10 6668.05 8071.05 1174.80  
## [593] 5435.00 2438.60 45.60 713.75 916.15 237.20 4614.55 1414.45  
## [601] 1170.50 47.70 4859.25 4903.20 3608.00 6094.25 3084.90 2356.75  
## [609] 8306.05 6786.40 248.95 663.05 1357.10 4860.35 3418.20 631.40  
## [617] 186.30 6976.75 4884.85 522.95 362.60 5755.80 3355.65 406.95  
## [625] 137.60 2395.70 1968.10 6819.45 7943.45 4547.25 4687.90 2473.95  
## [633] 6562.90 176.30 2236.20 6985.65 3109.90 4911.35 5794.65 855.30  
## [641] 1620.20 2499.30 89.55 4287.20 394.85 1899.65 45.70 3442.15  
## [649] 161.50 1732.60 222.30 74.60 655.30 475.25 164.30 865.10  
## [657] 6132.70 3597.50 35.90 697.65 96.05 428.70 20.05 4459.15  
## [665] 1167.60 238.10 145.15 1453.10 191.05 4039.30 1039.45 1336.10  
## [673] 75.05 493.40 2550.90 7246.15 1203.95 62.25 313.60 3775.85  
## [681] 80.00 4616.05 195.65 4188.40 71.10 49.90 1266.40 91.10  
## [689] 1623.40 4149.45 20.45 2344.50 1013.05 270.70 417.00 20.65  
## [697] 6316.20 168.15 4018.05 4811.60 4189.70 2848.45 2516.20 33.60  
## [705] 208.45 2015.35 3739.80 2964.00 2263.40 2211.80 19.55 1683.70  
## [713] 1519.00 1164.05 1710.90 4245.55 4145.90 2664.30 1277.50 5589.30  
## [721] 34.75 1305.95 381.30 141.50 3105.55 204.55 605.90 356.10  
## [729] 2758.15 4805.65 3941.70 92.75 1901.05 5730.70 2423.40 1653.45  
## [737] 3327.05 7085.50 3344.10 6697.35 2879.90 137.10 1008.55 1551.60  
## [745] 202.15 7882.25 8196.40 202.90 855.10 5817.00 1652.95 5600.15  
## [753] 515.75 2283.30 190.50 1842.80 1253.80 57.20 1269.55 6563.40  
## [761] 20.80 1907.85 208.85 4758.80 1292.60 363.15 1600.25 275.70  
## [769] 3089.10 1175.60 237.30 1444.65 19.90 454.15 3036.75 8065.65  
## [777] 92.50 184.65 6152.30 89.50 5154.50 220.45 1510.30 52.20  
## [785] 2588.95 4874.80 3983.60 2003.60 1832.40 4908.25 3590.20 5023.00  
## [793] 146.60 2339.30 298.70 143.65 2548.65 507.40 20.00 6125.40  
## [801] 5411.40 1058.25 903.80 3009.50 489.45 5468.45 1058.10 7616.00  
## [809] 4113.10 69.55 6017.65 7250.15 1108.20 938.65 94.15 2088.05  
## [817] 178.70 5656.75 2317.10 5986.45 6751.35 3566.60 4889.30 318.10  
## [825] 1563.95 1430.25 644.35 372.45 5453.40 1442.60 5610.70 963.95  
## [833] 5222.30 3340.55 292.80 5774.55 4487.30 44.40 2854.95 905.55  
## [841] 5509.30 7589.80 229.60 394.10 89.90 295.95 5459.20 444.75  
## [849] 6782.15 6510.45 8476.50 4461.85 62.00 352.65 1424.90 6413.65  
## [857] 6309.65 50.80 5898.60 4719.75 457.30 5822.30 1463.50 307.40  
## [865] 2104.55 319.15 2337.45 104.30 5084.65 121.25 7015.90 5598.00  
## [873] 1269.10 3027.40 4634.35 113.95 1582.75 3077.00 4039.50 1665.20  
## [881] 1043.30 504.20 497.55 7511.65 1782.00 20.05 609.65 2857.60  
## [889] 3247.55 6215.35 2823.00 5017.90 2619.25 24.60 4965.10 2679.70  
## [897] 8310.55 5682.25 1120.95 4914.90 27.55 923.50 1625.65 6068.65  
## [905] 5398.60 918.60 234.85 1231.85 170.90 7984.15 688.65 1288.30  
## [913] 7848.50 267.00 1798.90 73.55 1643.55 4807.45 2193.00 2239.40  
## [921] 1505.90 255.35 1189.40 4786.15 1820.90 2404.15 205.05 952.30  
## [929] 7039.45 2538.05 1212.85 2651.10 1304.80 360.10 435.45 308.05  
## [937] 2283.30 434.50 7118.90 320.45 531.55 382.20 2001.00 4919.70  
## [945] 5645.80 215.80 77.60 2896.55 3395.80 759.35 85.15 535.55  
## [953] 1253.15 955.15 2162.60 44.70 1813.35 245.15 2028.80 2723.75  
## [961] 220.45 365.80 551.95 4054.20 45.70 832.35 112.30 60.65  
## [969] 5550.10 174.80 90.55 4733.10 4048.95 1359.70 4542.35 7532.15  
## [977] 69.90 888.65 6383.35 1916.00 413.00 808.95 1886.40 86.60  
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## [6209] 4860.85 788.05 1266.35 470.95 688.20 387.70 845.25 560.60  
## [6217] 4230.25 4983.05 4113.15 25.70 521.00 471.85 5976.90 506.90  
## [6225] 4299.75 7548.60 1654.75 80.35 4551.50 6227.50 20.05 76.40  
## [6233] 514.00 57.50 1474.35 880.20 3270.25 69.95 3919.15 7285.70  
## [6241] 93.30 169.05 7658.30 5959.30 5295.70 4693.20 3512.90 5231.20  
## [6249] 3603.45 217.45 6875.35 19.25 2021.35 2564.95 5611.75 7610.10  
## [6257] 35.05 73.00 45.75 4543.95 450.40 1297.35 4442.75 1423.15  
## [6265] 4378.35 74.20 2716.30 70.10 450.65 1175.85 558.80 2220.10  
## [6273] 3283.05 142.35 4939.25 4237.50 335.95 33.20 7188.50 926.25  
## [6281] 1119.35 116.60 68.80 287.40 2341.55 1362.85 163.60 2254.20  
## [6289] 145.15 7752.30 6585.35 4786.10 3835.55 397.00 19.70 1027.25  
## [6297] 1580.10 7222.75 3769.70 4233.95 1680.25 3725.50 413.65 7707.70  
## [6305] 714.15 2497.20 8309.55 601.55 139.25 1888.25 2773.90 5409.75  
## [6313] 5643.40 197.70 401.30 3238.40 1573.05 79.15 235.80 1364.75  
## [6321] 1985.15 655.85 303.15 4335.20 647.50 1574.45 2748.70 2483.65  
## [6329] 6367.20 4904.20 2044.95 1794.80 7173.15 6441.40 7039.05 921.40  
## [6337] 4018.35 5448.60 20.25 49.90 2085.45 1358.85 5135.15 730.10  
## [6345] 2869.85 118.25 49.25 1108.60 1815.65 730.40 75.45 5071.05  
## [6353] 4014.60 568.85 5860.70 7279.35 1064.95 5769.60 5886.85 4238.45  
## [6361] 20.30 418.30 136.05 708.20 788.55 700.85 4378.80 3442.80  
## [6369] 181.70 7171.70 4016.85 553.00 96.85 4122.90 1482.30 74.30  
## [6377] 1240.80 44.65 1095.30 788.80 6578.55 19.55 2802.30 857.75  
## [6385] 184.40 364.55 6093.30 1861.10 20.40 1079.65 7475.10 2862.55  
## [6393] 3069.45 2349.80 469.25 4213.35 3301.05 3529.95 7723.70 4144.90  
## [6401] 4265.00 154.65 3246.45 8337.45 5731.40 6176.60 1905.40 931.90  
## [6409] 7348.80 776.25 5243.05 141.65 7679.65 2954.50 1006.90 2540.10  
## [6417] 3097.20 3807.35 2484.00 5785.65 2619.15 1524.85 2790.65 1784.50  
## [6425] 3937.45 2276.10 2029.05 802.35 418.40 4653.25 275.90 343.45  
## [6433] 2130.45 1191.40 50.50 2554.00 5589.45 467.70 74.40 3756.45  
## [6441] 3334.90 920.50 3431.75 150.35 2587.70 367.95 5125.75 4801.10  
## [6449] 6219.60 19.55 550.10 7862.25 1242.20 4871.05 3190.65 2666.75  
## [6457] 3533.60 792.15 295.65 1459.35 4398.15 4297.95 167.30 4096.90  
## [6465] 3454.60 1286.00 1387.00 786.30 641.25 705.45 345.50 345.90  
## [6473] 5811.80 94.40 124.45 1375.60 3491.55 7920.70 6640.70 55.00  
## [6481] 718.10 320.40 101.45 1334.45 3358.65 4764.00 350.30 5703.00  
## [6489] 69.50 18.85 525.55 69.20 483.15 934.80 786.50 69.65  
## [6497] 4086.30 5364.80 82.30 20.30 770.40 6816.95 2419.55 4138.70  
## [6505] 267.60 3457.45 1115.20 5435.60 4186.30 25.05 4630.20 3221.25  
## [6513] 688.50 867.10 4746.05 712.85 48.95 355.10 45.30 5764.70  
## [6521] 167.30 428.45 1505.35 693.45 930.40 1177.95 5069.65 324.25  
## [6529] 1458.10 156.40 2298.90 1679.65 369.60 2998.00 5206.55 3626.10  
## [6537] 24.40 7968.85 152.45 1959.50 2053.05 398.55 1130.85 3425.35  
## [6545] 4323.45 703.55 1275.70 2965.75 1647.00 56.25 2249.95 6109.75  
## [6553] 159.40 3751.15 68.65 411.25 105.50 3320.60 327.45 5669.50  
## [6561] 465.45 704.30 1369.80 1107.25 95.55 6375.20 8152.30 1566.75  
## [6569] 130.25 162.15 110.05 1885.15 6302.85 2264.50 816.80 1253.50  
## [6577] 41.20 5265.55 693.30 5997.10 3824.20 3886.05 7283.25 412.55  
## [6585] 1070.25 817.95 1171.30 6548.65 625.65 1911.50 70.85 134.70  
## [6593] 1507.00 2978.30 299.30 5832.65 5567.55 450.80 4166.35 1215.60  
## [6601] 91.70 7898.45 3915.40 979.50 90.05 7432.05 4026.40 25.30  
## [6609] 1193.05 20.10 398.55 1958.45 69.90 63.15 1301.10 484.05  
## [6617] 4528.00 3887.85 2208.75 238.15 80.80 958.15 118.30 76.45  
## [6625] 3845.45 1094.50 573.75 1267.00 633.45 6129.65 1218.25 1405.30  
## [6633] 2274.90 74.50 1068.85 533.90 676.15 3804.40 1118.80 5236.40  
## [6641] 1386.80 762.25 1902.00 239.05 5673.70 39.80 997.75 5574.35  
## [6649] 406.05 138.85 123.65 1801.10 689.00 790.70 582.50 1618.20  
## [6657] 1173.35 900.90 2122.05 6719.90 69.15 3784.00 1798.65 54.65  
## [6665] 3886.45 1224.05 2310.20 723.40 3988.50 3554.60 2283.30 6034.85  
## [6673] 531.60 85.10 173.00 2511.95 3893.60 357.15 467.50 2288.70  
## [6681] 4627.85 289.10 6460.55 1931.30 402.60 2221.55 7758.90 172.85  
## [6689] 224.50 7388.45 3460.95 1700.90 3090.65 1293.80 645.80 5224.95  
## [6697] 500.10 2427.10 3488.15 1035.70 7565.35 2799.00 1601.50 85.50  
## [6705] 6256.20 1232.90 19.90 1937.40 1096.25 5059.75 3023.65 4889.20  
## [6713] 2289.90 6503.20 1313.25 990.30 228.00 5746.15 209.10 1864.20  
## [6721] 5979.70 3902.45 7142.50 902.00 4481.00 805.20 154.85 528.45  
## [6729] 8349.70 4953.25 332.65 470.20 2259.35 1411.35 593.75 6328.70  
## [6737] 1411.90 6841.40 20.35 238.50 3233.85 1062.10 4016.30 226.55  
## [6745] 7110.75 5440.90 235.10 1958.95 85.00 5528.90 1463.70 1025.05  
## [6753] 552.10 3815.40 2283.30 3313.40 1938.90 3014.65 460.25 4839.15  
## [6761] 184.40 19.90 2010.55 5139.65 69.20 1673.40 309.35 3171.60  
## [6769] 8670.10 916.00 299.75 702.05 2354.80 3473.40 19.65 4438.20  
## [6777] 4819.75 92.25 1567.00 1242.45 559.20 220.10 531.15 1183.20  
## [6785] 465.85 6876.05 501.00 3782.40 460.20 20.20 1790.35 733.35  
## [6793] 1334.00 7767.25 876.15 4600.95 113.55 1793.25 886.70 7737.55  
## [6801] 1348.90 1686.85 1879.25 4013.80 434.50 7195.35 780.10 107.60  
## [6809] 3801.70 308.70 438.25 50.35 3778.10 3147.50 5438.95 5102.35  
## [6817] 70.30 1872.20 213.35 5617.75 5386.50 1776.95 2483.05 235.65  
## [6825] 5224.35 2272.80 83.75 4663.40 201.70 125.00 684.40 620.35  
## [6833] 1146.05 1806.35 603.00 5798.30 519.15 497.60 1301.70 1129.75  
## [6841] 19.30 266.95 257.00 865.80 2623.65 45.85 79.55 1082.80  
## [6849] 147.80 2570.20 4378.90 3616.25 2924.05 6014.85 32.70 2882.25  
## [6857] 1509.90 5305.05 2368.40 7985.90 3545.35 1301.00 372.45 2985.25  
## [6865] 77.75 564.35 95.45 1311.75 1135.70 2319.80 3720.35 5025.80  
## [6873] 5224.50 6185.80 1498.55 1208.60 6613.65 69.70 573.30 1818.90  
## [6881] 1787.35 1051.05 7181.25 3688.60 99.75 871.40 780.50 821.60  
## [6889] 239.45 244.45 3357.90 129.60 4977.20 365.35 334.65 2424.05  
## [6897] 43.95 4981.15 2090.25 45.10 4905.75 2038.70 4014.00 2441.70  
## [6905] 2751.00 1307.80 383.65 2868.05 449.75 53.55 7882.50 1087.70  
## [6913] 791.70 7493.05 4414.30 6841.30 819.95 6052.25 3361.05 4869.50  
## [6921] 509.30 4308.25 221.10 3833.95 69.35 294.95 4092.85 316.90  
## [6929] 2651.20 471.70 216.75 5720.95 503.25 69.60 7365.30 7245.90  
## [6937] 385.00 961.40 4615.90 3251.30 3880.05 3088.75 1396.00 30.50  
## [6945] 53.05 6859.50 2108.35 6770.50 4730.60 1151.05 232.55 1022.60  
## [6953] 5121.30 1127.20 309.40 523.10 4250.10 770.50 246.70 3342.00  
## [6961] 3930.60 1747.85 2754.45 897.75 2780.60 5895.45 2208.05 2196.15  
## [6969] 1692.60 20.50 265.35 1836.25 6418.90 4871.45 4947.55 1558.65  
## [6977] 4284.20 1218.25 5617.95 24.20 679.85 554.45 5237.40 2032.30  
## [6985] 789.20 1525.35 2804.45 3726.15 1652.10 1588.75 3366.05 778.10  
## [6993] 7113.75 4367.35 993.15 5012.35 2728.60 2093.40 1011.80 106.85  
## [7001] 1343.40 130.10 6794.75 1022.50 3691.20 486.20 4036.85 4685.55  
## [7009] 256.25 1917.10 74.45 272.15 5150.55 3756.40 3645.75 2874.45  
## [7017] 49.95 1020.75 70.65 826.00 239.00 727.80 7544.30 6479.40  
## [7025] 3626.35 1679.40 403.35 931.55 4326.25 263.05 39.25 3316.10  
## [7033] 75.75 2625.25 6886.25 1495.10 743.30 1419.40 1990.50 7362.90  
## [7041] 346.45 306.60 6844.50

# Churn Rate  
telcoCust1 <- telcoCust %>% group\_by(Churn) %>%  
 summarise(Count = length(Churn)) %>%  
 mutate(Rate = Count / sum(Count)\*100.0)  
#mutate as yes and no group  
ggplot(telcoCust1, aes(x = '', y = Rate, fill = Churn)) +  
 geom\_bar(width = 1, size = 1, color = 'blue', stat = 'identity') +  
 coord\_polar('y') +  
 geom\_text(aes(label = paste0(round(Rate), '%')),  
 position = position\_stack(vjust = 0.5)) +  
 labs(title = 'Churners Rate') +  
 theme\_classic() +  
 theme(axis.line = element\_blank(),axis.title.x = element\_blank(),axis.title.y = element\_blank(),  
 axis.ticks = element\_blank(),  
 axis.text = element\_blank())



# EDA  
telcoCust$MonthlyChargesBin <- NA  
telcoCust$MonthlyChargesBin[telcoCust$MonthlyCharges > 0 & telcoCust$MonthlyCharges <= 20] <- '20'  
telcoCust$MonthlyChargesBin[telcoCust$MonthlyCharges > 20 & telcoCust$MonthlyCharges <= 40] <- '40'  
telcoCust$MonthlyChargesBin[telcoCust$MonthlyCharges > 40 & telcoCust$MonthlyCharges <= 60] <- '60'  
telcoCust$MonthlyChargesBin[telcoCust$MonthlyCharges > 60 & telcoCust$MonthlyCharges <= 80] <- '80'  
telcoCust$MonthlyChargesBin[telcoCust$MonthlyCharges > 80 & telcoCust$MonthlyCharges <= 100] <- '100'  
telcoCust$MonthlyChargesBin[telcoCust$MonthlyCharges > 100 & telcoCust$MonthlyCharges <= 120] <- '120'  
telcoCust$MonthlyChargesBin[telcoCust$MonthlyCharges > 120 & telcoCust$MonthlyCharges <= 140] <- '140'  
telcoCust$MonthlyChargesBin[telcoCust$MonthlyCharges > 140 & telcoCust$MonthlyCharges <= 160] <- '160'  
telcoCust$MonthlyChargesBin[telcoCust$MonthlyCharges > 160 & telcoCust$MonthlyCharges <= 180] <- '180'  
telcoCust$MonthlyChargesBin <- factor(telcoCust$MonthlyChargesBin,   
 levels = c('20', '40', '60', '80', '100', '120', '140', '160', '180'))  
  
# Remove PhoneService & InternetService  
telcoCust1 <- telcoCust[,-c(7,9)]  
  
# Remove Customer ID, Phone Service, Internet Service & monthly charges column  
telco <- telcoCust[, -c(1, 7, 9, 19)]   
View(telco)

# Replace No Phone/Internet Service of all service columns  
telco$MultipleLines <- replace(telco$MultipleLines, telco$MultipleLines == 'No phone service', 'No')  
telco$OnlineSecurity <- replace(telco$OnlineSecurity, telco$OnlineSecurity == 'No internet service', 'No')  
telco$OnlineBackup <- replace(telco$OnlineBackup, telco$OnlineBackup == 'No internet service', 'No')  
telco$DeviceProtection <- replace(telco$DeviceProtection, telco$DeviceProtection == 'No internet service', 'No')  
telco$TechSupport <- replace(telco$TechSupport, telco$TechSupport == 'No internet service', 'No')  
telco$StreamingTV <- replace(telco$StreamingTV, telco$StreamingTV == 'No internet service', 'No')  
telco$StreamingMovies <- replace(telco$StreamingMovies, telco$StreamingMovies == 'No internet service', 'No')

# Churn Rate of top-tier customers  
topTierCust <- telcoCust1[which(telcoCust1$MultipleLines == 'Yes' & telcoCust1$OnlineSecurity == 'Yes' &   
 telcoCust1$OnlineBackup == 'Yes' & telcoCust1$DeviceProtection == 'Yes' &   
 telcoCust1$TechSupport == 'Yes' & telcoCust1$StreamingTV == 'Yes' &   
 telcoCust1$StreamingMovies == 'Yes'), ]  
paste0('Top-tier customers: ', round((length(which(topTierCust$Churn == 1)) / nrow(topTierCust))\*100, 2), '%')

## [1] "Top-tier customers: 5.29%"

#View(topTier)  
topTier = topTierCust[, c(2, 3, 4, 5, 6, 14, 15, 16, 20, 19)]  
names(topTier)

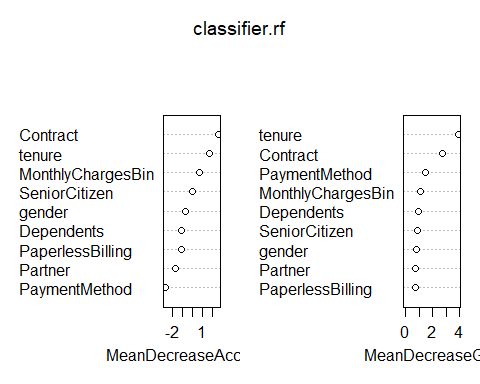
## [1] "gender" "SeniorCitizen" "Partner"   
## [4] "Dependents" "tenure" "Contract"   
## [7] "PaperlessBilling" "PaymentMethod" "MonthlyChargesBin"  
## [10] "Churn"

library(caTools)  
set.seed(234)# random sampling   
split = sample.split(topTier$Churn, SplitRatio = 0.7)  
trainingSet\_topTier = subset(topTier, split == TRUE)  
testSet\_topTier = subset(topTier, split == FALSE)

#Random Forest   
library(randomForest)  
set.seed(456)  
classifier.rf <- randomForest(as.factor(Churn) ~ gender + SeniorCitizen + Partner + Dependents + tenure + Contract + PaperlessBilling + PaymentMethod + MonthlyChargesBin, data = trainingSet\_topTier,importance = TRUE,ntree = 50)   
# ntree a number in which is divided into two part  
#classifier.rf  
summary(classifier.rf)

## Length Class Mode   
## call 5 -none- call   
## type 1 -none- character  
## predicted 146 factor numeric   
## err.rate 150 -none- numeric   
## confusion 6 -none- numeric   
## votes 292 matrix numeric   
## oob.times 146 -none- numeric   
## classes 2 -none- character  
## importance 36 -none- numeric   
## importanceSD 27 -none- numeric   
## localImportance 0 -none- NULL   
## proximity 0 -none- NULL   
## ntree 1 -none- numeric   
## mtry 1 -none- numeric   
## forest 14 -none- list   
## y 146 factor numeric   
## test 0 -none- NULL   
## inbag 0 -none- NULL   
## terms 3 terms call

varImpPlot(classifier.rf)



y\_Pred <- predict(classifier.rf, testSet\_topTier)  
confusionMatrix(testSet\_topTier$Churn, y\_Pred)

## Confusion Matrix and Statistics  
##   
## Reference  
## Prediction 0 1  
## 0 58 1  
## 1 3 0  
##   
## Accuracy : 0.9355   
## 95% CI : (0.843, 0.9821)  
## No Information Rate : 0.9839   
## P-Value [Acc > NIR] : 0.9967   
##   
## Kappa : -0.0248   
##   
## Mcnemar's Test P-Value : 0.6171   
##   
## Sensitivity : 0.9508   
## Specificity : 0.0000   
## Pos Pred Value : 0.9831   
## Neg Pred Value : 0.0000   
## Prevalence : 0.9839   
## Detection Rate : 0.9355   
## Detection Prevalence : 0.9516   
## Balanced Accuracy : 0.4754   
##   
## 'Positive' Class : 0   
##

View(telcoCust)

# Contract term  
paste0('The churn rate of month-to-month customers is ',  
 round(length(which(telcoCust$Contract == 'Month-to-month' & telcoCust$Churn == 1)) /   
 length(telcoCust$Contract == 'Month-to-month')\*100, 2), '%')

## [1] "The churn rate of month-to-month customers is 23.5%"

paste0('The churn rate of one year customers is ',  
 round(length(which(telcoCust$Contract == 'One year' & telcoCust$Churn == 1)) /   
 length(telcoCust$Contract == 'One year')\*100, 2), '%')

## [1] "The churn rate of one year customers is 2.36%"

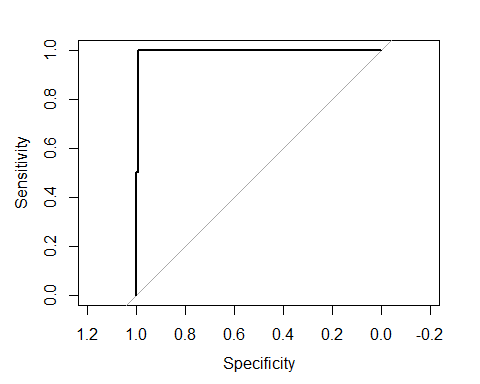
paste0('The churn rate of two year customers is ',  
 round(length(which(telcoCust$Contract == 'Two year' & telcoCust$Churn == 1)) /   
 length(telcoCust$Contract == 'Two year')\*100, 2), '%')

## [1] "The churn rate of two year customers is 0.68%"

#SVM  
  
svm\_fit <- svm(Churn ~ ., probability = TRUE, data = trainingSet\_topTier )  
svm\_fit

##   
## Call:  
## svm(formula = Churn ~ ., data = trainingSet\_topTier, probability = TRUE)  
##   
##   
## Parameters:  
## SVM-Type: C-classification   
## SVM-Kernel: radial   
## cost: 1   
## gamma: 0.05   
##   
## Number of Support Vectors: 34

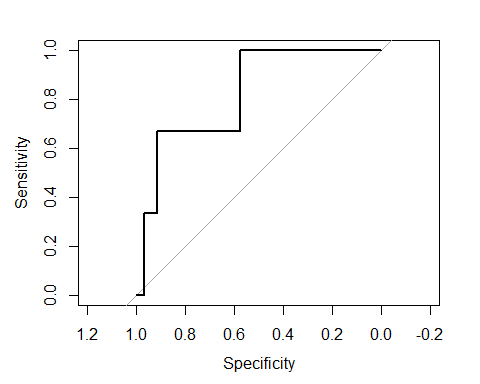
svm\_preds\_train <- predict(svm\_fit, trainingSet\_topTier, probability = TRUE)  
svm\_train\_probs <- data.frame(attr(svm\_preds\_train, "probabilities"))  
plot(roc(trainingSet\_topTier$Churn, svm\_train\_probs$X1))



svmroc\_train\_simple <- roc(trainingSet\_topTier$Churn, svm\_train\_probs$X1)  
svmauc\_train\_simple <- auc(svmroc\_train\_simple)  
svmauc\_train\_simple

## Area under the curve: 0.9964

svm\_preds\_test <- predict(svm\_fit, testSet\_topTier, probability = TRUE)  
svm\_test\_probs <- data.frame(attr(svm\_preds\_test, "probabilities"))  
plot(roc(testSet\_topTier$Churn, svm\_test\_probs$X1))



svmroc\_test <- roc(testSet\_topTier$Churn, svm\_test\_probs$X1)  
svmauc\_test <- auc(svmroc\_test)  
svmauc\_test

## Area under the curve: 0.8192

#We observe that the model is a good fit because the AUC values for training and test are high and similar. We may consider improving the SVM model by performing a grid search for values of C, gamma and degree of the kernel that gives higher accuracy using k-fold cross-validation.  
#Logistic Regression  
  
# Remove Customer ID, Phone Service, Internet Service & monthly charges column  
telco <- telcoCust[, -c(1, 7, 9, 19)]   
  
# Replace No Phone/Internet Service of all service columns  
telco$MultipleLines <- replace(telco$MultipleLines, telco$MultipleLines == 'No phone service', 'No')  
telco$OnlineSecurity <- replace(telco$OnlineSecurity, telco$OnlineSecurity == 'No internet service', 'No')  
telco$OnlineBackup <- replace(telco$OnlineBackup, telco$OnlineBackup == 'No internet service', 'No')  
telco$DeviceProtection <- replace(telco$DeviceProtection, telco$DeviceProtection == 'No internet service', 'No')  
telco$TechSupport <- replace(telco$TechSupport, telco$TechSupport == 'No internet service', 'No')  
telco$StreamingTV <- replace(telco$StreamingTV, telco$StreamingTV == 'No internet service', 'No')  
telco$StreamingMovies <- replace(telco$StreamingMovies, telco$StreamingMovies == 'No internet service', 'No')

# Building the optimal model using backward elimination  
library(stats)  
  
# Fit classifier to the dataset  
classifier <- glm(formula = Churn ~ .,  
 family = 'binomial',  
 data = telco)  
  
# identify variables using backward elimination  
classifier <- step(classifier, direction = 'backward')

## Start: AIC=5974.15  
## Churn ~ gender + SeniorCitizen + Partner + Dependents + tenure +   
## MultipleLines + OnlineSecurity + OnlineBackup + DeviceProtection +   
## TechSupport + StreamingTV + StreamingMovies + Contract +   
## PaperlessBilling + PaymentMethod + TotalCharges + MonthlyChargesBin  
##   
## Df Deviance AIC  
## - Partner 1 5924.2 5972.2  
## - gender 1 5924.4 5972.4  
## - DeviceProtection 1 5925.1 5973.1  
## <none> 5924.1 5974.1  
## - StreamingTV 1 5926.2 5974.2  
## - MultipleLines 1 5926.6 5974.6  
## - StreamingMovies 1 5926.8 5974.8  
## - Dependents 1 5928.8 5976.8  
## - OnlineBackup 1 5930.0 5978.0  
## - SeniorCitizen 1 5935.2 5983.2  
## - TotalCharges 1 5942.3 5990.3  
## - TechSupport 1 5952.1 6000.1  
## - OnlineSecurity 1 5953.6 6001.6  
## - PaperlessBilling 1 5956.0 6004.0  
## - PaymentMethod 3 5968.5 6012.5  
## - MonthlyChargesBin 5 5987.0 6027.0  
## - tenure 1 6024.6 6072.6  
## - Contract 2 6038.1 6084.1  
##   
## Step: AIC=5972.17  
## Churn ~ gender + SeniorCitizen + Dependents + tenure + MultipleLines +   
## OnlineSecurity + OnlineBackup + DeviceProtection + TechSupport +   
## StreamingTV + StreamingMovies + Contract + PaperlessBilling +   
## PaymentMethod + TotalCharges + MonthlyChargesBin  
##   
## Df Deviance AIC  
## - gender 1 5924.4 5970.4  
## - DeviceProtection 1 5925.1 5971.1  
## <none> 5924.2 5972.2  
## - StreamingTV 1 5926.2 5972.2  
## - MultipleLines 1 5926.6 5972.6  
## - StreamingMovies 1 5926.8 5972.8  
## - Dependents 1 5929.5 5975.5  
## - OnlineBackup 1 5930.0 5976.0  
## - SeniorCitizen 1 5935.5 5981.5  
## - TotalCharges 1 5942.4 5988.4  
## - TechSupport 1 5952.1 5998.1  
## - OnlineSecurity 1 5953.6 5999.6  
## - PaperlessBilling 1 5956.0 6002.0  
## - PaymentMethod 3 5968.6 6010.6  
## - MonthlyChargesBin 5 5987.0 6025.0  
## - tenure 1 6025.0 6071.0  
## - Contract 2 6038.1 6082.1  
##   
## Step: AIC=5970.39  
## Churn ~ SeniorCitizen + Dependents + tenure + MultipleLines +   
## OnlineSecurity + OnlineBackup + DeviceProtection + TechSupport +   
## StreamingTV + StreamingMovies + Contract + PaperlessBilling +   
## PaymentMethod + TotalCharges + MonthlyChargesBin  
##   
## Df Deviance AIC  
## - DeviceProtection 1 5925.3 5969.3  
## <none> 5924.4 5970.4  
## - StreamingTV 1 5926.4 5970.4  
## - MultipleLines 1 5926.8 5970.8  
## - StreamingMovies 1 5927.1 5971.1  
## - Dependents 1 5929.7 5973.7  
## - OnlineBackup 1 5930.2 5974.2  
## - SeniorCitizen 1 5935.8 5979.8  
## - TotalCharges 1 5942.5 5986.5  
## - TechSupport 1 5952.3 5996.3  
## - OnlineSecurity 1 5953.7 5997.7  
## - PaperlessBilling 1 5956.2 6000.2  
## - PaymentMethod 3 5968.9 6008.9  
## - MonthlyChargesBin 5 5987.3 6023.3  
## - tenure 1 6025.2 6069.2  
## - Contract 2 6038.3 6080.3  
##   
## Step: AIC=5969.3  
## Churn ~ SeniorCitizen + Dependents + tenure + MultipleLines +   
## OnlineSecurity + OnlineBackup + TechSupport + StreamingTV +   
## StreamingMovies + Contract + PaperlessBilling + PaymentMethod +   
## TotalCharges + MonthlyChargesBin  
##   
## Df Deviance AIC  
## - StreamingTV 1 5927.3 5969.3  
## <none> 5925.3 5969.3  
## - StreamingMovies 1 5927.9 5969.9  
## - MultipleLines 1 5928.0 5970.0  
## - Dependents 1 5930.7 5972.7  
## - OnlineBackup 1 5931.0 5973.0  
## - SeniorCitizen 1 5936.7 5978.7  
## - TotalCharges 1 5943.2 5985.2  
## - TechSupport 1 5953.7 5995.7  
## - OnlineSecurity 1 5954.4 5996.4  
## - PaperlessBilling 1 5957.4 5999.4  
## - PaymentMethod 3 5970.3 6008.3  
## - MonthlyChargesBin 5 5987.4 6021.4  
## - tenure 1 6026.4 6068.4  
## - Contract 2 6042.0 6082.0  
##   
## Step: AIC=5969.28  
## Churn ~ SeniorCitizen + Dependents + tenure + MultipleLines +   
## OnlineSecurity + OnlineBackup + TechSupport + StreamingMovies +   
## Contract + PaperlessBilling + PaymentMethod + TotalCharges +   
## MonthlyChargesBin  
##   
## Df Deviance AIC  
## <none> 5927.3 5969.3  
## - MultipleLines 1 5929.6 5969.6  
## - StreamingMovies 1 5930.4 5970.4  
## - Dependents 1 5932.5 5972.5  
## - OnlineBackup 1 5933.5 5973.5  
## - SeniorCitizen 1 5938.5 5978.5  
## - TotalCharges 1 5945.4 5985.4  
## - TechSupport 1 5955.3 5995.3  
## - OnlineSecurity 1 5957.4 5997.4  
## - PaperlessBilling 1 5960.2 6000.2  
## - PaymentMethod 3 5973.2 6009.2  
## - MonthlyChargesBin 5 5999.7 6031.7  
## - tenure 1 6028.1 6068.1  
## - Contract 2 6042.3 6080.3

summary(classifier)

##   
## Call:  
## glm(formula = Churn ~ SeniorCitizen + Dependents + tenure + MultipleLines +   
## OnlineSecurity + OnlineBackup + TechSupport + StreamingMovies +   
## Contract + PaperlessBilling + PaymentMethod + TotalCharges +   
## MonthlyChargesBin, family = "binomial", data = telco)  
##   
## Deviance Residuals:   
## Min 1Q Median 3Q Max   
## -1.8692 -0.7025 -0.2905 0.7326 3.4256   
##   
## Coefficients:  
## Estimate Std. Error z value  
## (Intercept) -1.1584264 0.1800693 -6.433  
## SeniorCitizen1 0.2792302 0.0832956 3.352  
## DependentsYes -0.1835786 0.0805872 -2.278  
## tenure -0.0566821 0.0061309 -9.245  
## MultipleLinesYes 0.1210102 0.0800674 1.511  
## OnlineSecurityYes -0.4563750 0.0839345 -5.437  
## OnlineBackupYes -0.1935930 0.0778352 -2.487  
## TechSupportYes -0.4459391 0.0849453 -5.250  
## StreamingMoviesYes 0.1517842 0.0853702 1.778  
## ContractOne year -0.7769263 0.1060737 -7.324  
## ContractTwo year -1.5398925 0.1739701 -8.851  
## PaperlessBillingYes 0.4185645 0.0732658 5.713  
## PaymentMethodCredit card (automatic) -0.0734528 0.1131169 -0.649  
## PaymentMethodElectronic check 0.3784082 0.0933542 4.053  
## PaymentMethodMailed check -0.1491074 0.1127946 -1.322  
## TotalCharges 0.0002976 0.0000716 4.157  
## MonthlyChargesBin40 0.4602844 0.1754231 2.624  
## MonthlyChargesBin60 0.9323477 0.1735501 5.372  
## MonthlyChargesBin80 1.1741521 0.1756034 6.686  
## MonthlyChargesBin100 1.4229276 0.1942970 7.323  
## MonthlyChargesBin120 1.7837095 0.2529982 7.050  
## Pr(>|z|)   
## (Intercept) 1.25e-10 \*\*\*  
## SeniorCitizen1 0.000801 \*\*\*  
## DependentsYes 0.022726 \*   
## tenure < 2e-16 \*\*\*  
## MultipleLinesYes 0.130698   
## OnlineSecurityYes 5.41e-08 \*\*\*  
## OnlineBackupYes 0.012875 \*   
## TechSupportYes 1.52e-07 \*\*\*  
## StreamingMoviesYes 0.075412 .   
## ContractOne year 2.40e-13 \*\*\*  
## ContractTwo year < 2e-16 \*\*\*  
## PaperlessBillingYes 1.11e-08 \*\*\*  
## PaymentMethodCredit card (automatic) 0.516111   
## PaymentMethodElectronic check 5.05e-05 \*\*\*  
## PaymentMethodMailed check 0.186189   
## TotalCharges 3.22e-05 \*\*\*  
## MonthlyChargesBin40 0.008694 \*\*   
## MonthlyChargesBin60 7.78e-08 \*\*\*  
## MonthlyChargesBin80 2.29e-11 \*\*\*  
## MonthlyChargesBin100 2.42e-13 \*\*\*  
## MonthlyChargesBin120 1.79e-12 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## (Dispersion parameter for binomial family taken to be 1)  
##   
## Null deviance: 8150.1 on 7042 degrees of freedom  
## Residual deviance: 5927.3 on 7022 degrees of freedom  
## AIC: 5969.3  
##   
## Number of Fisher Scoring iterations: 6

# Remove the variables from the dataset  
telco1 <- telco[, c(2, 4, 5, 7, 8, 10, 12, 13, 14, 15, 16, 17, 18)]  
  
# split the dataset into training set & test set  
library(caTools)  
set.seed(123)  
split = sample.split(telco1$Churn, SplitRatio = .7)  
trainingSet <- subset(telco1, split == TRUE)  
testSet <- subset(telco1, split == FALSE)  
  
# Feature Scaling  
trainingSet[c(3,11)] = scale(trainingSet[c(3,11)])  
testSet[c(3,11)] = scale(testSet[c(3,11)])

# Fitting classifier to the Training set  
classifier <- glm(formula = Churn ~ .,  
 family = 'binomial',  
 data = trainingSet)  
summary(classifier)

##   
## Call:  
## glm(formula = Churn ~ ., family = "binomial", data = trainingSet)  
##   
## Deviance Residuals:   
## Min 1Q Median 3Q Max   
## -1.8609 -0.6868 -0.2754 0.7251 3.4307   
##   
## Coefficients:  
## Estimate Std. Error z value Pr(>|z|)  
## (Intercept) -2.27568 0.21533 -10.568 < 2e-16  
## SeniorCitizen1 0.27672 0.10038 2.757 0.00584  
## DependentsYes -0.19817 0.09815 -2.019 0.04349  
## tenure -1.47296 0.18660 -7.894 2.93e-15  
## OnlineSecurityYes -0.46817 0.10187 -4.596 4.31e-06  
## OnlineBackupYes -0.22614 0.09314 -2.428 0.01518  
## TechSupportYes -0.52479 0.10338 -5.076 3.85e-07  
## StreamingMoviesYes 0.09907 0.10206 0.971 0.33166  
## ContractOne year -0.82374 0.13090 -6.293 3.12e-10  
## ContractTwo year -1.51401 0.21028 -7.200 6.03e-13  
## PaperlessBillingYes 0.42495 0.08849 4.802 1.57e-06  
## PaymentMethodCredit card (automatic) 0.01335 0.13700 0.097 0.92234  
## PaymentMethodElectronic check 0.45124 0.11363 3.971 7.15e-05  
## PaymentMethodMailed check -0.11702 0.13753 -0.851 0.39484  
## TotalCharges 0.77288 0.19814 3.901 9.59e-05  
## MonthlyChargesBin40 0.30301 0.20812 1.456 0.14541  
## MonthlyChargesBin60 0.94515 0.20159 4.688 2.75e-06  
## MonthlyChargesBin80 1.12879 0.20176 5.595 2.21e-08  
## MonthlyChargesBin100 1.44525 0.22046 6.556 5.54e-11  
## MonthlyChargesBin120 1.83800 0.28749 6.393 1.62e-10  
##   
## (Intercept) \*\*\*  
## SeniorCitizen1 \*\*   
## DependentsYes \*   
## tenure \*\*\*  
## OnlineSecurityYes \*\*\*  
## OnlineBackupYes \*   
## TechSupportYes \*\*\*  
## StreamingMoviesYes   
## ContractOne year \*\*\*  
## ContractTwo year \*\*\*  
## PaperlessBillingYes \*\*\*  
## PaymentMethodCredit card (automatic)   
## PaymentMethodElectronic check \*\*\*  
## PaymentMethodMailed check   
## TotalCharges \*\*\*  
## MonthlyChargesBin40   
## MonthlyChargesBin60 \*\*\*  
## MonthlyChargesBin80 \*\*\*  
## MonthlyChargesBin100 \*\*\*  
## MonthlyChargesBin120 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## (Dispersion parameter for binomial family taken to be 1)  
##   
## Null deviance: 5704.4 on 4929 degrees of freedom  
## Residual deviance: 4069.0 on 4910 degrees of freedom  
## AIC: 4109  
##   
## Number of Fisher Scoring iterations: 6

# Predicting the Test set results  
threshold = 0.5  
probPred = predict(classifier, type = 'response', newdata = testSet[-12])  
y\_Pred <- ifelse(probPred > threshold, 1, 0)

# Confusion Matrix - simplest but relies on 1 testSet, not relevant  
confusionMatrix(table(testSet$Churn, y\_Pred))

## Confusion Matrix and Statistics  
##   
## y\_Pred  
## 0 1  
## 0 1389 163  
## 1 282 279  
##   
## Accuracy : 0.7894   
## 95% CI : (0.7714, 0.8066)  
## No Information Rate : 0.7908   
## P-Value [Acc > NIR] : 0.5762   
##   
## Kappa : 0.4208   
##   
## Mcnemar's Test P-Value : 2.222e-08   
##   
## Sensitivity : 0.8312   
## Specificity : 0.6312   
## Pos Pred Value : 0.8950   
## Neg Pred Value : 0.4973   
## Prevalence : 0.7908   
## Detection Rate : 0.6574   
## Detection Prevalence : 0.7345   
## Balanced Accuracy : 0.7312   
##   
## 'Positive' Class : 0   
##

# K-folds cross validation  
library(caret)  
set.seed(456)  
folds <- createFolds(trainingSet$Churn, k=10)  
cv <- lapply(folds, function(x) {  
 training\_fold <- trainingSet[-x, ]  
 test\_fold <- trainingSet[x, ]  
 classifier <- glm(formula = Churn ~ .,  
 family = 'binomial',  
 data = training\_fold)  
 threshold = 0.5  
  
 probPred = predict(classifier, type = 'response', newdata = test\_fold[-12])  
 y\_Pred <- ifelse(probPred > threshold, 1, 0)  
 cm = table(test\_fold[, 12], y\_Pred)  
 accuracy = (cm[1,1] + cm[2,2]) / (cm[1,1] + cm[2,2] + cm[1,2] + cm[2,1])  
 return(accuracy)  
})  
  
accuracy = mean(as.numeric(cv))  
accuracy

## [1] 0.801827